Maturation Of Instruments For Solar System Exploration

The Search for Extra-Terrestrial Genomes (SETG)

Completed Technology Project (2015 - 2017)

Project Introduction

Background: Widespread synthesis of complex organics, including nucleobases and ribose precursors, occurred early in the history of the solar system in the solar nebula. These organics, delivered by comets and meteorites to multiple potentially habitable zones (Earth, Mars, Enceladus, Europa, Titan) may have biased the evolution of life towards utilization of similar informational polymers. Meteoritic exchange might also have produced shared ancestry, most plausible for Earth and Mars. We propose to continue development of the ASTID-funded Search for Extra-Terrestrial Genomes (SETG), a life detection instrument for in-situ sequencing of nucleic acids. Science Goals: Our mission focus area is astrobiology and the search for life beyond Earth. Our science goal for Mars is to search for related or unrelated nucleic acid-based life, particularly life that has the potential to interact with life on Earth; this may also inform sample selection for Mars Sample Return (MSR) and reduce the risks of false positives through the first in-situ measurement of forward contamination. Our science goal for Enceladus is to search for a second genesis based on nucleic acids in the plumes emanating from the South Polar Region. Life detection may also be possible in Europa orbit but the availability of a suitable plume is tenuous and it is a challenge for biological reagents to survive intense radiation there. Objectives: The objectives of this proposal are to 1) advance SETG component/subsystem development through validation in lab and relevant environments, 2) integrate instrument components into a single automated end-to-end system, and 3) assess and validate instrument performance and limits of detection (expected to be ppb or better) using synthetic and environmental samples, including operation under Mars temperature and pressure. Methodology: We will apply advances in nucleic acid extraction and concentration to enable high-yield isolation of high-purity nucleic acids, followed by nanopore-based detection and single-molecule sequencing-by-synthesis. This effort will include stabilization of all reagents. B. subtilis spores will be used to validate detection limits down to 50 spores, with testing to 10 spores. To further assess system performance, we will use other synthetic and environmental samples, carry out bench top and field validation, and operation under Mars-like temperature and pressure conditions; this will advance SETG from TRL 3 to TRL 6 in preparation for future flight definition. Relevance: SETG addresses the NASA Science Plan question 'How did life begin and evolve on Earth and has it evolved elsewhere in the solar system?' and the corresponding objective to 'Identify and investigate past or present habitable environments on Mars and other worlds, and determine if there is or has ever been life elsewhere in the solar system.' Our effort is responsive to Decadal Survey priorities, including Mars Sample Return, Europa Orbiter, and the moderate-priority Enceladus orbiter. Why MATISSE? First, SETG requires substantial additional development and validation before flight definition, and addresses the specified TRL range. Second, our effort will help to provide heritage for a new class of instruments that utilize biological components to enable a range of new capabilities at extremely low power, mass, and volume. Third, we cannot envision a discovery that would be higher payoff than the

The Search for Extra-Terrestrial Genomes (SETG)

Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Maturation of Instruments for Solar System Exploration

Project Management

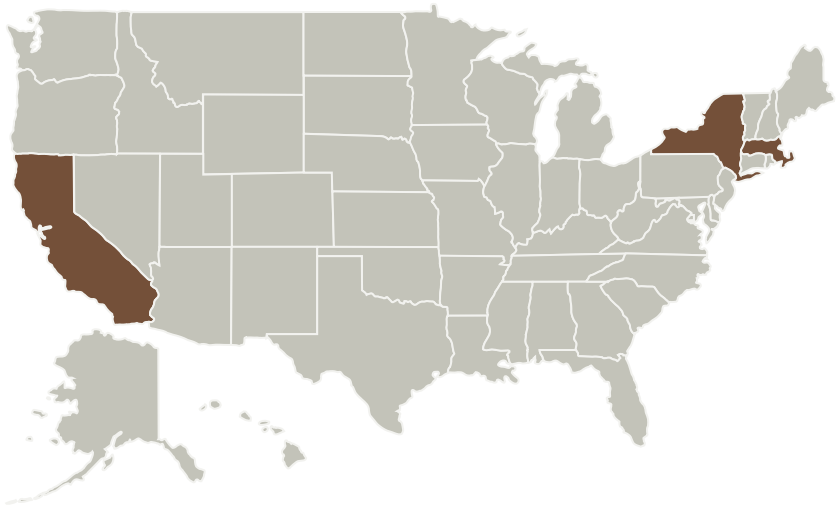
Program Director:

Carolyn R Mercer

Continued on following page.

indisputable identification of life beyond Earth, which SETG is uniquely positioned to do. Finally, SETG also has significant Earth applications ranging from environmental monitoring to clinical diagnosis.

Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations	
California	Massachusetts
New York	

Project Management *(cont.)*

Program Manager:

Haris Riris

Principal Investigator:

Maria T Zuber

Co-Investigators:

Robert W Doebler
George Church
Gary B Ruvkun
Carl W Fuller
Christopher Carr
Nancy A Sahagian
Michael J Finney

Technology Areas

Primary:

- TX04 Robotic Systems
  - TX04.3 Manipulation
    - TX04.3.4 Sample Acquisition and Handling

Target Destination

Others Inside the Solar System